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ABSTRACT

This paper first traces the historical development of speech compression technology, which has made it possible to alter the spoken rate of a pre-recorded message without excessive distortion. Terms used to describe techniques employed as the technology evolved are discussed, including rapid speech, rate altered speech, cut-and-spliced speech, and speech sampling. A review of the research on the effects of speech compression on intelligibility and listening comprehension and their associated variables highlights methods of compression, linguistic factors, prior experience, binaural presentation, comprehension, degree of compression, listening and lecturer variables, pauses, training effect, retention, listener preference and acceptance, and degree of difficulty. Past instructional uses are examined in an additional research review which focuses on speech compression as it relates to visuals, individualized instruction, independent study, and reading instruction. The paper concludes with a state-of-the-art summary and a discussion of the implications as they provide a foundation and rationale for further study. A six-page reference list is included. (LMM)

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COMPRESSED SPEECH TECHNOLOGY: IMPLICATIONS FOR LEARNING AND INSTRUCTION

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COMPRESSED SPEECH TECHNOLOGY: IMPLICATIONS FOR LEARNING AND INSTRUCTION

A B S T R A C T

For decades it has been known that man could think much more rapidly than he could speak. Until recently, however, it was not possible to instructional capitalize on this realization. Now a new technology - speech compression - has made it possible to alter the spoken rate of a pre-recorded message without excessive distortion. The end result is a substantial savings in the time required to learn recorded instructional material. It is the purpose of this work to trace the historical development of the compressed speech technology, analyze its early experimentation, review its past and present instructional uses, and discuss the implications of the current state of the art to the technology's instructional future.

INTRODUCTION

Technology's exponential growth since the orbiting of Sputnik I in 1957 has thrust our society into an escalating period of unrestrained information expansion. Conservative estimates predict that man's acquired knowledge will literally double every ten years during the next half century (States & Lien, 1974). Although the body of knowledge that man must master is growing rapidly, the time that he has to accomplish the task remains forever constant. With only twenty-four hours in each day, man must continually seek more efficient ways of digesting ever-increasing volumes of written and spoken information.

In its written form, new information can be reviewed by reading at a rate consistent with the reader's intention. The reader may vary his or her reading rate from highly accelerated skimming and scanning to methodical and deliberate reading for detail and subtle nuances of meaning. With specialized training, reading speeds in excess of one-thousand words per minute have been successfully attained.

Typically, the same flexibility has not been available with regard to the large volumes of spoken information man encounters. In this modality, the listener has little or no control over the rate at which spoken information is presented. Since the average speaking rate is approximately 125-175 words per minute, learning by listening would appear to be a grossly inefficient endeavor. This

would be particularly true if man were limited to only original live spoken presentations. For decades, however, technology has allowed us the capability of recording and then replaying spoken material. Like the printed word, the recording has afforded us the opportunity to review the spoken word upon demand. Until recently, however, we have not been able to effectively alter the rate at which spoken information was presented.

The desirability of altering the spoken presentation rate rests on the assumption that man can effectively process orally presented information faster than he normally speaks. Early work by Nichols (1955) clearly demonstrated that man's speed of thought far exceeds his rate of speech. Exploration of this intriguing issue was, however, hampered by the nonavailability of an acceptable device or technique to successfully vary spoken presentation rate.

In the seventies, the development of a device called the speech compressor allowed for the variable acceleration or deceleration of prerecorded spoken material without excessive distortion. The evolution of this practical and affordable technological innovation has now opened the doors for serious inquiry into a new instructional concept which this author calls "speed listening".

Speed listening is defined as the technique whereby the listener consciously determines the appropriate presentation rate for prerecorded material consistent with his or her own objectives rather than those of the original speaker.

It is the intention of this work to: (1) trace the historical development of the speech compression technology; (2) review the research concerning its effects on intelligibility and listening comprehension and their associated variables; (3) examine its past instructional uses; and (4) summarize the state of the art and discuss the implications as they provide a foundation and rationale for further study.

History of Speech Compression

Speech compression is a relatively new technology. In its development, a wide variety of approaches and techniques have been employed. As the technology evolved, the terms by which it was described changed. The terms "rapid speech", "accelerated speech", "rate-altered speech", "rate controlled recording," and "compressed speech" have all been used at one time or another. Each of these terms had relevance to the technique employed and period during which the research was conducted. Some of these terms have persisted while others have been supplanted by those more universally accepted. Since the technology is still evolving, no totally standard terminology has yet been adopted. For consistency and clarity, the prevailing terms will be defined as the history of the technology is discussed.

Rapid Speech

The idea of presenting the spoken message at a rate faster than normal has intrigued researchers for years.

Since no technology existed to facilitate such acceleration, early efforts involved training speakers to increase their rate of oral presentation. This technique was referred to as "rapid speech". Early research by Goldstein (1940) and later studies by Nelson (1948) and Hardwood (1955) concentrated on the concept of rapid speech. In these studies, the speakers were trained to increase their presentation rate of speech to above a 300 words-per-minute (wpm) rate. This technique was troublesome since few individuals could sustain this accelerated presentation rate and articulation problems were frequently encountered (Calearo & Lazzaroni, 1957; deQuiros, 1964). Miron and Brown (1968) established that trained speakers could not maintain rates in excess of 225 wpm for extended periods of time.

Given its obvious limitations and disadvantages, rapid speech could yield rates of presentation far in excess of the rate of normal speech. For experimental purposes, normal speech rate has been defined and measured differently. The normal oral reading rate, as produced in the reading of a prepared script, falls in a range between 125 to 175 wpm (Foulke, 1968). The normal rate of spontaneous speech has been found to vary from person to person and from time to time depending on the situation and the speaker's state of mind (Latz, 1977). During a lecture or in a conversation in which the speaker is deliberately formulating the expression of his ideas as

he speaks the rate is typically slower. On the other hand, the disc jockey or auctioneer frequently speaks at a much higher or accelerated rate.

Comparison of the average adult's speaking rate of approximately 150 wpm with the average silent-reading rate of 275 wpm reveals that an individual can read and comprehend continuous prose faster than it is normally spoken. It is also evident that the human being can think faster than they normally speak. For example, while speaking one sentence it is very possible for the speaker to choose between several ways of phrasing the next sentence. While listening to a speech, the listener is able to think of several other topics and still follow the thread of the speaker's argument. These observations stimulated early researchers to explore the potential usefulness of increased oral presentation rate using the only technique then available, namely, rapid speech. Although this early work was far from conclusive, it did suggest potential merit for further research, particularily if a better technique could be found to systematically produce quality accelerated speech.

Rate-Altered Speech

Rather than requiring the speaker to speak at an abnormally rapid rate, researchers next attempted recording the oral presentation at its normal speed and then changing or altering the rate at which it was played back. Technically, it was very easy to double the rate of presentation by playing

back the taped message at twice the speed. Since the frequencies of all components of the voice signal were also doubled by this technique, the overall pitch of the reproduced voice was raised by one octave. The resulting distortion, frequently referred to as the "Donald Duck Effect", was considered intolerable to the majority of listeners. Latz (1977) reported that only moderate accelerations in rate of presentation, up to approximately 25% increase, could be tolerated by the average listener. Since such a limited alteration was possible with this technique, it was abandoned in search of a better technological solution.

Cut and Spliced Speech

The next major approach in compression was a technique known as "cut and splice". Several such studies were conducted including one by Miller and Licklider (1955) of Harvard University. Their technique involved cutting out small sections of recorded tape, substituting blank sections, and splicing the two together. In this form, part of the voice signal was removed but no speech compression was gained. Garvey modified the Miller-Licklider cutting method to effectively increase the rate of presentation. In this variation, the tape was measured in centimeters with every other centimeter being removed. The alternate segments were then spliced together without blank tape. In comparing his tapes with tapes at normal speed, Garvey found that his method produced a compression

effect without the associated pitch distortion which adversely affected comprehension. This method, while successful, was too difficult and time consuming to be practical.

Speech Sampling

Since Miller and Licklider (1950) had experimentally established that large portions of a speech signal could be eliminated without seriously affecting the listener's ability to recognize the words presented to them, a speech sampling approach was next considered. Miller and Licklider employed a switching device which periodically turned the speech signal on and off. It was determined that if the switching occured more rapidly than ten times per second, the interrupted speech was readily understood. Listeners were able to correctly identify 90% of the words used in the experiment even when half the speech signal was eliminated.

Fairbanks, Everitt, and Jaeger (1954) devised an experimental electromechanical apparatus which served the sampling function as the Miller and Licklider switching device. Fairbanks' equipment randomly deleted segments of the tape using four playback heads. The unreproduced samples were short enough so that discarded portions would not contain an entire speech sound. Every speech sound in the original recording was sampled, resulting in a speech compressed tape which was unaffected with respect to vocal pitch. The Fairbanks' technique was further refined and

two speech compression devices, the Eltro Information Rate Changer and the Whirling Dervish, were subsequently marketed. Since these compressors retained normal pitch, they were easy to understand. They were, however, expensive to purchase ($3,000 - $5,000) and difficulty to operate and maintain.

Another approach to the sampling technique involved the use of computer processing. Many experimented with programming a computer to perform sampling according to a predetermined rule (Ball, 1961; Scott, 1965; Qureshi, 1974; and Seo, 1974). Others used the computer to shorten or eliminate natural pauses or parts of vowel sounds (Miron & Brown, 1968). Suen (1971) used the computer to delete and extract speech patterns displayed as wave forms on an oscilloscope. Although these computer based techniques were the most satisfactory methods of speech compression at that time, they were too complicated and expensive to be used for anything but research.

Sampling by use of a speech synthesizer was still another approach tried to generate quality speech compression (Campanella, 1967 and Bayless, Campanella & Goldberg, 1973). With this technique, the input speech signal was analyzed in terms of standardized speech features and converted into digital-coded form. After sampling, the output speech signal is synthesized to closely resemble the original speech but in a compressed form. Although this technique was of value in settings where a signal must be transmitted and received at a distant site, it had little applicability

in a nonbroadcast environment.

Breuel and Levens (1974) further demonstrated that speech could be compressed by means of a harmonic compressor. In this technology, the energy in a speech signal is distributed among 36 frequency bands. A frequency divider is used to reduce its frequency by half and all outputs are then recombined. Passing this frequency distorted signal through a harmonic compressor restored the component frequencies and produced an undistorted speech presentation at twice the original rate. Although the quality of compressed speech was superior, doubling the presentation rate was typically too difficult for the listener to handle. Like other techniques previously discussed, this approach could not produce compressed speech at rates less than double the original. For this reason it had little practical value.

All the approaches reviewed thus far have had serious limitation with regard to their practicality or affordability. Although the speech sampling techniques appeared to show the most promise, it was not until the last 1960's that the application of solid state electronic technology moved speech compression toward a technical breakthrough. Several inventors and entrepreneurs began developing prototype speech compressors by the turn of the decade. These equipment developments were highlighted in the News Bulletin of the Center for Rate Controlled Recordings (Foulke, 1973).

In a technical report, Lee (1972) described a speech compression and expansion sampling technique using a dedicated minaturized digital computer to perform pitch correction. This approach yielded the Varispeech I and its successor Varispeech II produced by Lexicon, Inc. Schiffman (1974) described another variation where electronic signal-sampling and restoration is inserted into the playback audio output chain which also produces speech compression or expansion without distortion. Magnetic Video Corporation produced variable speech control Copycorder model CC-103 using this technique of compression. PKM Corporation produced the Vocom-I and Vocom-II compressors which were designed to delete pauses and other parts of the speech signal, if necessary, to further increase the speech presentation rate. By the mid 1970's all of these devices were actively being marketed in the $500 to $1,300 price category. More recently the Variable Speech Control (VSC) Company has entered two additional models into the market with one, model A7, listing under $300.

Intelligibility and Comprehension

Research on the usefulness of compressed speech as a viable instructional innovation has focused heavily on the effects of compression on the intelligibility and comprehension of the material. The ability of the listener to accurately repeat single words or brief phrases has been employed as a measure of intelligibility (Foulke & Sticht, 1969). Lehiste and Peterson (1959) defined intelligibility

as the property of speech communication which involves individual meaning. In contrast, listening comprehension involves hearing a continuous speech passage compressed to a given word rate then testing the listener's ability to answer questions on the facts and implications of that passage. Since these two approaces place different demands on the learner, it is not surprising that findings were somewhat different.

Intelligibility

Various characteristics of the stimulus material and the listener have been shown to have effects on the intelligibility of compressed speech. The following sub sections will highlight these factors and influences.

Method of compression. The intelligibility of compressed words has been shown to be influenced by the technique of compression used. Compression by the rate-altered speech method yielded a loss of intelligibility of approximately 40 percent when the test words were compressed so that they are heard in only two-thirds of the time required for their production (Garvey, 1953). Due to this and other inherent limitations, this technique of compression was abandoned. Compression using the speech sampling method resulted in a much smaller loss in intelligibility. When this technique was used, intelligibility depended on the duration of the discarded portion of the sampling period. The part that is cut out must be relatively short when compared to the speech sounds to be sampled. If not, the speech sound may be completely eliminated. With words compressed to 50

percent of their original durations, Garvey (1953) using discard intervals of 40, 60, 80, 100 milliseconds, found intelligibility scores of 95.33 percent, 95.67 percent, 95 percent and 85.67 percent, respectively. Kodman (1954) found substantial losses in intelligibility when the discard interval was greater than 80 milliseconds.

Linguistic factors. Compression by the rate-altered speech method degraded the intelligibility of vowel sounds more than consonant sounds, whereas compression by the speech sampling method yielded the reverse (Kurtzrock, 1957). Klumpp and Webster (1961), using the rate altered speech method, found that short phrases were more intelligible than single words. The redundancy provided by the context and sequencing effects of short phrases most probably aided intelligibility.

Prior Experience. Garvey (1953), using words compressed by the speech sampling method, found that repeated hearing of such words improved their intelligibility. Henry (1966) found that words which have greater frequency of occurrence in the language, according to the Thorndike and Lorge (1944) word count, were more intelligible.

Binaural Presentation. Cramer (1965) delayed the signal to one earphone by 7.5 milliseconds to give binaural redundancy and to increase the intelligibility of compressed speech. Using a technique referred to as dichotic speech, Scott (1965) presented compressed speech in one ear and the discarded samples in the other ear. With this technique

he observed increased intelligibility scores.

Comprehension

It has also been observed that several stimulus and listener related factors have effects on the comprehension of compressed speech. It is also evident that the comprehension of orally presented connected discourse is influenced by the intelligibility of the individual words of which that discourse is composed. Factors affecting intelligibility have, therefore, effects on comprehension as well. There are, however, consistent findings that intelligibility declines less rapidly with greater degrees of compression than does comprehension (Foulke & Sticht, 1969).

Degree of compression. The relationship between the degree of compression and the resultant impact on comprehension has been a topic of considerable study. The means of testing comprehension as well as the experimental methodology used has varied between experiements thus making direct comparisons difficult. There has, however, been a surprising degree of unanimity among the findings.

For example, Diehl, White, and Burke (1959) found no significant change in listening comprehension with changes in the rate of presentations between 126-272 wpm. Without reference to actual word rates, Nelson (1948) and Harwood (1955) found slight but insignificant loss in listening comprehension as wpm increased. A study by Harwood, conducted seven years later, yielded similar findings. Fairbanks, Guttman and Miron (1957) found little difference in comprehension of listening selections at 141, 201, and 282 wpm.

Thereafter, comprehension (as indicated by the percentage of test questions correctly answered) declined from 58 to 26 percent at 282 and 470 wpm, respectively. Foulke and Sticht (1967) found an initial moderate linear loss in comprehension as the degree of compression increased toward what appeared to be a threshold effect at approximately 275 wpm. In general, a rapidly accelerating decline in comprehension has been consistently reported at word rates in excess of approximately 275 wpm regardless of the percentage of compression required to achieve that rate (Fairbanks, Guttman, and Miron, 1957; Foulke and Sticht, 1967; and Goldstein, 1940).

The reason that comprehension declines after 275 wpm is reached may be because the listener's channel capacity has been attained (Miller, 1956), and further increases in information cannot be handled. Silent reading rates in excess of 275 wpm are common without precipitous comprehension declines because the reader is able to reduce the number of elements to be processed by "chunking" (perceiving an entire phrase). In oral language, however, words are displayed sequentially and the listener cannot chunk (Foulke, 1968). Within the 275 wpm parameter these findings suggest a trade-off between slightly lowered comprehension test scores and savings in listening time. By dividing the listener's

comprehension score by the time required to hear the speech passage, Fairbanks, Guttman and Miron (1957) generated a unit of measurement called the "index of learning efficiency of compressed speech." Using this index, they found that learning efficiency increased as word rate was increased until a word rate of 280 wpm was reached. These findings were also confirmed by later experiments (Enc and Stolurow, 1960; Foulke, Amster, Nolan, and Bixler, 1962).

Method of compression. No consistent superiority of speech sampling method over the rate-altered speech method of compression has been shown in tests of comprehension of a listening selection (Foulke and Sticht, 1969). For tests of intelligibility it was noted previously that the speech sampling method was superior. This indicates that the comprehension of connected discourse, presented in compressed form, involves more than merely the intelligibility of the individual words of which the passage is composed.

Listener and Lecturer Variables. Some evidence has been presented which would suggest that certain learner and lecturer variables affect comprehension of compressed speech. With respect to the gender of the listener, several studies (Foulke and Sticht, 1967; McCracken, 1971; Orr, Friedman and Williams, 1965) showed no sex related differences in listenting comprehension for presentation rates from 125 to 475 wpm. Michel-Miller (1970) reported

no significant change in heart rate of a student listening to word rates up to 325 wpm. Contrary opinions on sex differences were, however, noted in the literature. For example, McCracken (1971) did find that males had a higher galvanic skin response (GSR) than females but reported less stress on their written reaction sheets than females when listening to tapes at 320 wpm. In a study of professional adults, Parker (1972) found that males significantly outscored females. This study supported an earlier one by Goldhaber and Weaver (1968) in which college students were the participants. Results of the data indicated that a significant difference was found when the difficulty rate of the presentation and the sex of the listener varied. The males outscored females in all tests, with comprehension differing significantly at two of the four compression speeds used (175 wpm and 325 wpm). This last study did not take into account the relation of topics to the past experience and knowledge of the subjects.

Many researchers have found a positive relationship between intelligence of the listener and the ability to comprehend compressed speech (Fairbanks et al., 1957; Goldstein, 1940). Fergan (1955) and Wood (1965) found a positive relationsip between grade level of school children and the comprehension of accelerated speech. Lopez (1974) stated that there was no evidence that the grade level of adults in a basic education course influences

comprehension of compressed speech. A significant positive correlation was reported between reading rate and the ability to comprehend accelerated tapes (Orr et al.,1965).

Foulke (1964) studied the effect upon the listener's comprehension when different speakers recorded the same material. He compressed the same material read by three different readers to 275 wpm. The administration of a listening comprehension test over this material showed that significant differences were associated with the speaker variable and with the word-rate variable. However, the speaker's effect of listening comprehension did not depend upon the word rate at which the selection was presented.

Pauses. Pauses were found to be extremely important when discussing compressed speech. According to Miron and Brown (1968), the listener, when actively decoding, supplies pause junctions and will tolerate a wide variation in pauses from the speaker. However, Miron concluded that the best method of compressing speech is to keep the pause time proportional and maintain a relative distribution of pauses. Goldman-Eisler (1974) stated that pauses reflect internal decision making, a time for encoding and decoding information. Friedman and Johnson (1969) found that inserting pauses between major segments within sentences resulted in higher recall on tests than inserting pauses between sentences. He used normal as well as compressed speech.

Training Effect. Orr (1964) reported that listening is a skill that is not equally well developed in all learners. He further postulated that individuals can significantly improve their listening skills when trained with increased compression rates. In a subsequent study Orr et. al (1965) demonstrated an increase in comprehension following several weeks of training at 325 wpm and 475 wpm. Voor and Miller (1965), using college students, also showed comprehension increased after practice. The comprehension increased and remained constant at speeds of 380 wpm.

In an experiment using blind students, Resta (1968) demonstrated that as little as two hours of practice in listening made a significant positive change in comprehension when compared to a group of blind students not having been exposed to practice periods.

As before, there were contradictory findings on this topic. Wasserm (1974) found with sighted college students that practice procedures did not appear to help comprehension as measured by objective tests. The greatest effect seemed to be due to the amount of exposure to compressed speech rather than to the practice given.

McCarty (1973) divided adult subjects into three groups and reported that the group that received no introduction to compressed speech prior to instruction was negatively biased. The group that was told to listen more carefully had no difficulty with the content immediately, one day, one week, and at one, two, or three month periods.

McCarthy noted that students with higher mental abilities retained more factual information than did students of lower mental abilities.

Foulke (1964) using blind students who were experienced listeners found no significant difference between pre- and post- training test scores. For sighted students, there seems to be a time period to adjust to the unfamiliar task of listening to speeded tapes. Sticht (1972) postulated that untrained sighted people who listen to compressed speech may attend to the word elements of the message and the rate of speech. Training this population may result in having them ignore the rate of speech and individual words and to concentrate more on the concepts being presented. Sticht states that field-independent persons (having the ability to keep things apart), who are also skilled in making rapid semantic analyses, could presumably comprehend highly speeded speech with little, if any, experience with such speech.

Retention. Foulke (1966) and Friedman, Graae and Orr (1967), testing comprehension at several different word rates at various time intervals, concluded that there was no difference in the degree of retention of material heard in compressed form and material heard at normal rates. George (1970) found no evidence that material forgotten, after it was originally comprehended, was differently affected by the rate of presentation.

Arrasjid (1973) gave an achievement post test one

week after college students listened to compressed speech tapes and found no decrease in retention as measured by achievement tests when compared with those who heard the same material using normal speed tapes. Those students given performance objectives to use with compressed tapes did better on their tests than students who were not given objectives.

Cicardo (1974) studied retention of compressed speech with junior high school students. Retention losses were found to increase as time between treatment and testing became greater. Testing for various groups was done immediately, one day, one week, and at one, two, or three month periods. It was noted that students with higher mental levels retained more factual information than did students on lower mental levels of achievement. In a previously reviewed study of professional adults, Parker (1972) found that males significantly outscored females in the retention task.

Listener Preference and Acceptance. Listener preference has been studied and reported in a variety of experimental settings and with various types of listeners. In a study involving adults and their listening rate preference, Cain and Lass (1974) found that of the nine rates tested, 100 wpm to 300 wpm, when rank-ordered, the preferred rate was 175 wpm. In an experiment cited by Orr (1968) in which the participants were allowed to vary

the rates of presentation, it was found that the average choice was approximately one and a half times the normal word rate. Under similar conditions, Foulke and Sticht (1966) found a rate of 207 wpm preferred by college students. Nath (1978), using professional pharmacists, reported listener acceptance up to the 50 percent compression rate.

Degree of difficulty. In addition to other insights already reported, Foulke and Sticht (1969) also stressed consideration of the impact of textual degree of difficulty on comprehension of compressed speech passages. Using Flesch's (1966) Reading Ease Formula, Goldhaber and Weaver (1968) presented college students with three compressed speech passages at the graduate, college freshman, and eight grade levels of difficulty. Results of this experiment indicated that the material rated at the freshman level yielded significantly higher comprehension scores. Foulke (1962) also suggested that scientific type selections appeared to be intrinsically more difficult than literary passages even when equated by the Reading Ease Formula. The type of subject matter being used may, therefore, effect comprehension differently.

Compressed Speech Instructional Uses

Although the work is not extensive, there have been some attempts to apply the compressed speech technology in various educational settings. Most of this research involves combining speech compression with some other instructional media, modality, or technique in an attempt

to produce more efficienty learning of some learning skill or body of knowledge. This section will review these endeavors clustered together by type.

Compressed Speech With Visuals

Some research has been done using compressed speech in association with an accompanying visual representation. Dunathan, Masterson, Parks, and Tharpe (1975) found, when working with sixth grade students, that instructional Super 8 mm sound motion pictures can be compressed at rates up to 50 percent without significantly affecting performance quality in a motor task (building a simple boat). The audio portion of the film was compressed to rates of 25, 33, 1/3, and 50 percent while comparable compressions of the film were made by varying the ratio of projector to camera speed.

Using compressed speech for the audio part of video-tapes, Ludrick (1974) force-paced two groups of 20 students through 16 videotaped modules at two rates of speech (150 wpm and 211 wpm) while two other groups were allowed to self-pace at both rates of speed. There was no difference between the forced pace and the self-paced groups, but those given the compressed speech (211 wpm) achieved at a higher level than those who used the normal rate programs (150 wpm).

Panasonic has recently announced that in early 1981 it will market a new ½ inch video system - Omnivision II VHS NV-8200 video cassette recorder/NV-8170 video cassette player - which has, among other things, a variable speed video display feature. With this device the video program could be presented a rates between one-fifth to twice the normal speed. Future experimentation will, therefore,

be possible with simultaneous compression or expansion of both the video and audio signals.

Compressed Speech and Individualized Instruction

In an attempt to demonstrate the usefulness of compressed speech in individualized instruction, Sarenpa (1971) studied a biology course taught by the Audio-Tutorial method. One group of 29 subjects listened to the 22 modules at a normal speech (from 113-138 wpm) while another group of 28 subjects heard the same lessons precompressed (193-238 wpm) by the pause deletion method. Time spent on each module was measured by time card and time clock handled by the student. There was no significant difference in achievement between the group using compressed tapes and those using normal speed tapes, but the compressed speech group did show a saving in time.

In a different approach to individualization, Hass (1974) allowed students to listen to lecture tapes (precompressed 50 percent by the pause deletion method) once a week. In the other class sessions, students attended regular lecture or discussion groups. On the final examination, students performed better on the questions based on the tapes than on questions based on the live lectures. Eighty-two percent of the 150 students stated that they would prefer a combination of compressed tapes, lecture and discussion groups rather than all live lectures.

Speech Compression and Independent Study

Employing an independent study approach, Challis (1973)

used students enrolled in a basic audiovisual course to determine if compressed speech tapes could be used in an independent study laboratory setting. The 96 students were divided into a control group, a group using tapes compressed by 30 percent, a group using tapes compressed by 40 percent, and a group that could choose from six different rates of compression. There was no significant difference on achievement scores of the four groups, and no significant difference between subjects with high grade point averages and those with low grade point averages using the same rates of speed. Challis found no difference on midterms and final examinations between achievement and time spent in the learning laboratory. Students filled out time sheets and turned them in at the end of the period. It was concluded that students using tapes precompressed by 30 percent had a 17 percent saving of time while students using tapes compressed by 40 percent saved 31 percent over the normal listening time. Fifty-seven percent of the students answered an attitude questionnaire. Of these, 91 percent expressed favorable attitudes toward compressed speech while 71 percent indicated that they would choose 30 percent or 40 percent compression for future use.

Primrose (1974) studied the feasibility of incorporating compressed speech into a dial access information retrieval system at Oral Roberts University. The machine used to precompress the tapes deleted pauses and at

higher compressions deleted portions of the vowel sound. It is not possible with this machine to accurately predetermine the compression rate, but the resulting tapes ranged from 200 to 324 wpm. The speed was gradually increased throughout the semester. Using a "fast rate of compression," it was reported that the machine had a "popping" sound which was distracting to the students. Students could listen to normal or compressed tapes for lecture or for review. Since the experimenters could not determine which students selected compressed tapes, they had imprecise data on the relative influence of speeded tapes on student grades. However, it was concluded that there was no significant difference on grades between those using compressed tapes and those using normal speed tapes. "Many students" did report that they preferred using speeded tapes for lectures, although nearly one-half of the students preferred listening to the original lectures. High achieving students used more compressed speed tapes when listening to lectures than did the average or lower aptitude students.

In an experiment reported by Short (1975) a semester-long college course which had previously been taught by self-paced audiovisual methods was presented to a randomly chosen half of the enrolled students (total enrollment was 90 students) by means of variable speed compressors. The other students listened to identical recordings from normal speed tape recorders. It was found that of those students assigned to use the compressors, 70 percent

"quickly adapted to and liked listening at faster than normal rates". Forty percent of these students regularly listened at word rates in the range of 276-320 words per minute which was approximately twice the normal speed. The group of students who used the compressors saved significant amounts of time and gained significantly higher scores on the achievement tests included in the course.

Nath (1978) also demonstrated the usefulness and efficiency of compressed speech in a study of this technique in the continuing education of practicing pharmacists. Using 73 pharmacists from Alabama and Georgia, he confirmed that professionals in this field could successfully comprehend compressed rate of 75% but observed that acceptance of the compression technique deteriorate beyond 50% compression.

Compressed Speech and Reading Instruction

Another area in which compressed speech may prove to be valuable is in the improvement of reading skills. It is anaccepted fact that reading rate, in particular, can be positively effected by progressive external pacing. This pacing has traditionally been provided visually by electronic or machinical reading machines, accelerators or skimmers. Several investigators have speculated that compressed speech might provide a useful alternate pacing technique. The findings in this area are, however, somewhat sketchy and inconclusive.

Early work on this notion was conducted by Orr (1964 &1966) who first reported that using rapid auditory material to pace reading resulted in significant increases in reading speed without loss in reading comprehension scores. Reiland (1970) using sixth grade students, reported contrary findings. In her investigation she found no significant difference when progressive auditory pacing supplemented silent reading. Johnson (1971), working with fourth grade students confirmed Reiland's non significant results. This investigator cautioned, however, that the non benefical effects may be a function of the learner's age and stage of human development. Credence to this observation was provided by Thames & Rossiter (1972) when they examined the effect of progressive compressed speech auditory pacing on 46 high school sophomores of average ability. Using this age group they found significant increases in reading rate without loss in reading comprehension in as few as 10 practice sessions of 30 minute duration. Musial and Maple (1975), using eighth grade subjects, reported a positive but non significant trend in favor of auditory pacing. This study was, however, fundamentally different from those previously reported in that a constant rather than progressive auditory pacing technique was used.

A study by Winters (1975) further documented the fact that the impact of the compressed speech auditory pacing technique was of different value to various types of students. This experiment reported the reading

comprehension of seventh grade learning disabled students with reading difficulties was positively effected by listening to passages with compressed speech. The benefit of the auditory pacing technique with students of low reading ability was further suggested by Shennum (1975). Using 26 adult navy training recruits, he reported a significant reading rate gain with an associated 20 percent gain in reading comprehension for the progressive auditory pacing experimental group in comparison to a non treatment control group. He did, however, also report a significant gain for the non-paced experimental group. He concluded that the experiment's precise goal setting and feedback procedure coupled with strong teacher encouragement motivated the non paced group to higher levels of achievement.

Pierce (1978) presented evidence that for normal students the junior high school years appeared to be the developmental stage at which the beneficial effects of auditory pacing began to be manifested. In this experiment he demonstrated significant gains in reading rate while simultaneously maintaining reading comprehension proficiency.

State of the Art Discussion

Based on the preceeding review, several generalizations about the technology and its instructional uses can be drawn. First, with respect to the technology itself, the

speech sampling technique has proven to be superior from both a practical and affordable vantage point. The advances in electronic miniturization have now made it possible to insert a digital computer speech processing unit into a standard size tape recorder. As was true with the pocket calculator, the cost of such modified recorders is expected to steadily decline in the future. The end result may be a speech compressor that is well within the budget of virtually every learner and teaching institution.

With regard to the issue of intelligibility and comprehension of compressed speech, the literature is not so conclusive. Some important generalizations can, however, be made. The evidence is persuasive that listening efficiency is not markedly retarded until the rate of compression of novel material exceeds the 275-300 wpm range. The threshold effect for review of familiar material would appear to be even higher. Since this listening efficiency threshold is approximately twice the normal speech rate, the opportunity to save substantial portions of time without a learning loss would appear to have important learning and instructional implications.

A technological innovation of this type has questionable applicability if it is not accepted by its potential users. Both the literature and this author's personal experience with the technology suggest an initial wariness by the untrained listener. This wariness can quickly turn into rejection if the listener is confronted with high

degrees of compression without a phased introduction. With an appropriate assimilation period, however, acceptance has been documented up to a compression rate at least one and a half times normal. Some research further suggests that training with progressively compressed speech materials may result in better overall listening skills. If this is true, some reason that the resultant improved listening skills might allow the trained listeners to successfully manage presentation rates even higher than the original threshold would suggest. As stated before, a contrary view has been offered which considers the 275 wpm threshold for novel material to be more of an absolute barrier due to man's intrinsic auditory information processing limitations. More research is needed to resolve this particular issue.

In the instructional applications area, research has been modest. Uses of compressed speech in conjunction with other visual display techniques has been limited by technical considerations. Its obvious beneficial use in individualized instruction and independent study with the adult learner has been preliminarily documented. Research in the use of compressed speech as an external pacer in the training of reading skills has shown some initial promise. In this latter area in particular, the type of learner being addressed appears to be an important variable. Although not unanimous, the body of literature suggests that external auditory pacing is only consistently

effective with learners at or above the junior high school level. Those at stages of mental age and development below this level seem to receive lesser benefit from this reading rate development technique.

Taken as a whole, research into the instructional uses of compressed speech could be accurately described as limited but promising. Compressed speech has clearly established itself as a saver of institutional time. On the other potential benefits of the technology the jury is still out. To realize its full instructional potential considerable more research and experimentation is needed.

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